PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Hameed Ullah

Cycle: XXXVII

Training and Research Activities Report

Year: First

Tutor: Fabio Ruggiero

Date: October 31, 2022

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: **Author:**

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1. Information:

- ➢ **PhD student: Hameed Ullah**
- ➢ **DR number: 157880**
- ➢ **Date of birth: 08/05/1992**
- ➢ **Master Science degree: Electrical Engineering   University: National University of Sciences and Technology Islamabad, Pakistan**
- ➢ **Doctoral Cycle: XXXVII**
- ➢ **Scholarship type: AEROTRAIN Project under _Marie Curie Scholarship Funded by EU._**
- ➢ **Tutor: Fabio Ruggiero**
- ➢ **Co-tutor:**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
AERO-TRAIN PhD Data Management Plan webinar - part 1	Seminar	1	0.2	20.12.2021	**Jitlka Stilund Hansen, DTU, Denmark**	**Y**
AERO-TRAIN PhD Data Management Plan webinar - part 2	Seminar	1	0.2	20.01.2022	**Jitlka Stilund Hansen, DTU, Denmark**	**Y**
Training School on Unmanned Aerial Systems for Inspection and Maintenance	Training School	28	2.0	7-11 March 22	**University of Seville, Spain**	**Y**
Using delays for control	Seminar	2	0.4	21 and 28 April 2022	**Prof. Emilia Fridman**	**Y**
Introduction to Deep Learning for Natural Language Processing & Explainable Natural Language Inference	Seminar	2.5	5	13/4/22	**Prof. Francesco Cutugno**	**Y**
AERO-TRAIN 1st Exploitation Workshop: Intellectual Property Management	Seminar	2	0.4	26/4/2022	**Julian Cayero Becerra Lead of Aerial Robotics Research at Eurecat**	**Y**

Potential and challenges of next generation railway signaling systems: Moving Block and Virtual Coupling	Seminar	1	0.2	06/04/22	Eng. Joelle Aoun	Y
Service and companion robots in healthcare	Seminar	1.5	0.3	21/4/2022	Pasquale Arpaia	Y
IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors	Seminar	1.5	0.3	30.03.2022	IEEE	Y
Springer Nature Author Workshop: Open Access and Transformative Agreements in Italy	Seminar	1	0.2	12/04/2022	Spring Nature	Y
On using simple optimization techniques for tuning of UAVs	Seminar	2	0.4	27/4/2022	Fabio Ruggiero	Y
Field and Service Robotics	Course	48	6	7 march to 9 june 2022	Prof. Fabio Ruggiero	Y
Robotics Lab	Course	48	6	7 march to10 june 2022	Dr. Jonathan Cacace	Y
5G FWA project, Engineering and Implementation Process Phases and Actors	Seminar	5	1	17/05/2022	A. Delugan, L. Mazza and M. Fazzari	Y
5G Networks in Action – The PrivateMobileEra	Seminar	1.5	0.3	11/05/2022	Ing. Marco Centenaro Ing. Nicola Di Pietro. Ing. Daniele Munaretto	Y
Vine Robot: Design Challenges and unique opportunities	Seminar	1	0.2	31/5/2022	Mario Selvaggio	Y
Shared Autonomy in Physical Human-Robot Interaction: Adaptability and Trust	Seminar	8	1.6	23/5/2022	Mario Selvaggio, ICRA 2022	Y
Training School on Autonomous systems	Training School	28	2	13-17 Jun 2022	Matteo Fumagalli	Y

working in uncertain environments					**DTU Denmark**	
Robot Interaction Control	**Course**	48	6	**7 march to 9 june 2022**	**Prof. Bruno Siciliano**	**Y**
Multi-Robot Systems	Summer School	**50**	**2**	**1-5 Aug 2022**	**Martin Saska, Czech Technical University, Prague, Czech Republic**	**Y**

1) Courses, Seminar, Doctoral School, Research, Tutorship
2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	**Seminars**	**Research**	**Tutorship**	**Total**
Bimonth 1	**0**	**0.2**	**9.8**	**0**	**10**
Bimonth 2	**0**	**0.2**	**9.8**	**0**	**10**
Bimonth 3	**2**	**2.7**	**5.3**	**0**	**10**
Bimonth 4	**12**	**1.3**	**3.7**	**0**	**17**
Bimonth 5	**10**	**1.8**	**3.2**	**0**	**15**
Bimonth 6	**0**	**0**	**10**	**0**	**10**
Total	**24**	**6.2**	**41.8**	**0**	**72**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

The scholarship is associated with the project AERO-TRAIN "AErial RObotic TRAINing for the next generation of European infrastructure and asset maintenance technologies", which is a Marie-Sklodowska-Curie Innovative Training Network (ITN) - European Training Network (ETN) project. The main aim of the AERO-TRAIN project is to take a step further toward the research of aerial manipulators which face the challenges of the Operations & Maintenance industry of civil and industrial infrastructures by deploying innovative aerial robotic solutions to reduce the risks and costs associated with field operations by humans.

The PhD topic mainly focuses on the stabilization and control of aerial manipulators while having physical in contact with the surrounding environment for on-site measurements. The main objectives of the PhD project are to design a model-based control for an aerial device or an aerial manipulator while interacting with the environment for on-site measurements. In addition to study aerodynamic hurdles caused by the proximity of the floating platform to the surrounding environment. Moreover, to develop estimators of unmodelled aerodynamic effects and external disturbances and test them in real-life experiments.

In the first year of the PhD, we did a comprehensive literature study and the state-of-the-art recent research work on the quadrotors and aerial manipulators. Manipulation in robotics received much attention in the last few years. To satisfy more requirements from society, aerial manipulators (UAM) are introduced, which unify aerial locomotion and manipulation to allow unmanned aerial vehicles to physically interact with the environment. Aerial manipulators present multiple scientific and technological gaps and a need for real-life testing to enable a broader spectrum of new technological capabilities. The AERO-TRAIN project aims to fill the gap between scientific research and industrial needs, which is a necessary aspect for developing new markets and applications.

The carried-out research activity focuses on designing a robust controller to stabilize the aerial manipulator during push and slide operations while perform manipulation tasks. Before going to discuss about aerial manipulators and physical operation, it is necessary to understand the mathematical modelling of the aerial platform. Therefore, during the first year of the PhD, we focused on studying the mathematical modelling of a quadrotor and an aerial manipulator, so that to design a robust controller. After properly deriving and understanding the mathematical model of a quadrotor, we started work on various controllers. Start from simple linear controllers like PI, PD, PID, and some other optimization controller like LQG and MPC. Furthermore, this year, the research work focused on nonlinear model predictive control (NMPC), which is a powerful robust nonlinear controller technique to handle complex nonlinear systems. Moreover, we started work on the state of the art of the NMPC, its understanding, and then implementation on a simple system. In addition, we implemented NMPC on a quadrotor on MATLAB/ Simulink and get the desired results. We are currently moving forward to implement NMPC on aerial manipulators while performing push and slide operations during physical tasks.

On the other hand, the "Field and service robot" course allowed to acquire the necessary knowledge, deep understanding of the mathematical modelling and control of the quadrotors and aerial manipulators. The "Robotics lab" course allowed to understand the basics of ROS and Gazebo which will be useful in future to implement experimental validation. Moreover, the participation in the IEEE RAS Summer School on Multi-Robot System, which was held in Czech Technical University, Prague, Czech Republic, has been a great opportunity to interact with international experts and exchange ideas about aerial robotics and multi-robots. Furthermore, in the first year of this PhD, two Training Schools have been attended. The former on "Unmanned Aerial Systems for Inspection and Maintenance" and the other on "Autonomous systems working in uncertain environments", organized by Aerotrain at University of Seville Spain and Technical University of Denmark, respectively. Both these training school not only helped to share information and build strong research networks with other PhD students and expert/senior researchers, but also to deeply understand the inspection and maintenance of aerial systems working in uncertain environments for physical interaction.

4. Research products:

Not yet.

5. Conferences and seminars attended

Not Yet.

6. Activity abroad:

No Abroad Period yet.

7. Tutorship

NO Tutorship.